



# 2017 Final Report Summary Sheet

## Grantee Information

**Project Title:** Bioreactors for Illinois: Smaller, Better, Faster

**Institution:** University of Illinois

**Primary Investigator:** Christianson

**NREC Project #** 2017-4-360498-302

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**Is your project on target from an IMPLEMENTATION standpoint?**  Yes  No

**If you answered "no" please explain:** We are still waiting to finalize a contractor for installation of several bioreactors. The designs have already been created, so we plan bioreactor installation to occur this spring or summer (just a few months behind schedule). Thank you for your patience!

**Is your project on target from a BUDGET standpoint?**  Yes  No

**If you answered "no" please explain:** There is a significant amount within the contractual budget line remaining as we wait to finalize our land improvement/drainage contractor.

**Based on what you know today, will you meet the objectives of your project on-time and on-budget?**  Yes  No

**If you answered "no" please explain:**

**Have you encountered any issues related to this project?**  Yes  No

**If you answered "yes" please explain:** It has been harder than I thought to identify/coordinate with contractors, but this is by no means an insurmountable challenge.

**Have you reached any conclusions related to this project that you would like to highlight?**  Yes  No

**If you answered "yes" please explain:**

**Have you completed any outreach activities related this project? Or do you have any activities planned?**  Yes  No

**If you answered "yes" please explain and provide details for any upcoming outreach:** We have presented at a variety of field events, and have a new bioreactor factsheet that will be hot off the presses in mid-February (see the following report).

**Additional Notes:**

**NREC January 2018 1.0 Year Report**  
**Bioreactors for Illinois: Smaller, Better, Faster**

PI: Dr. Laura Christianson, Assistant Professor of Water Quality, Department of Crop Sciences, University of Illinois, S322 Turner Hall, 1102 S Goodwin Ave., Urbana, IL 61801.

Co-PI: Dr. Richard Cooke, Agricultural and Biological Engineering, University of Illinois

1. **List of objectives**

The specific assessable objectives are to:

1. **Design** and **build** four new types of denitrifying bioreactors in Illinois:
  - a. Two Ditch Bioreactors (Private Farm)
  - b. One High-Flow Booster Bioreactor (Monmouth Farm, UIUC)
  - c. One Heat-Enhanced Bioreactor (South Farm, UIUC)
2. **Compare** the nutrient removal efficiency and hydraulic performance of these novel bioreactors to existing conventional bioreactors
3. Perform an **economic evaluation** (\$ per acre treated and \$ per pound of nitrogen removed).
4. Per the RFP, the final objective is *“to include a final report at the conclusion of this project to address each of the objectives stated above.”*

2. **Length of project - number of years completed:** 1.0 years

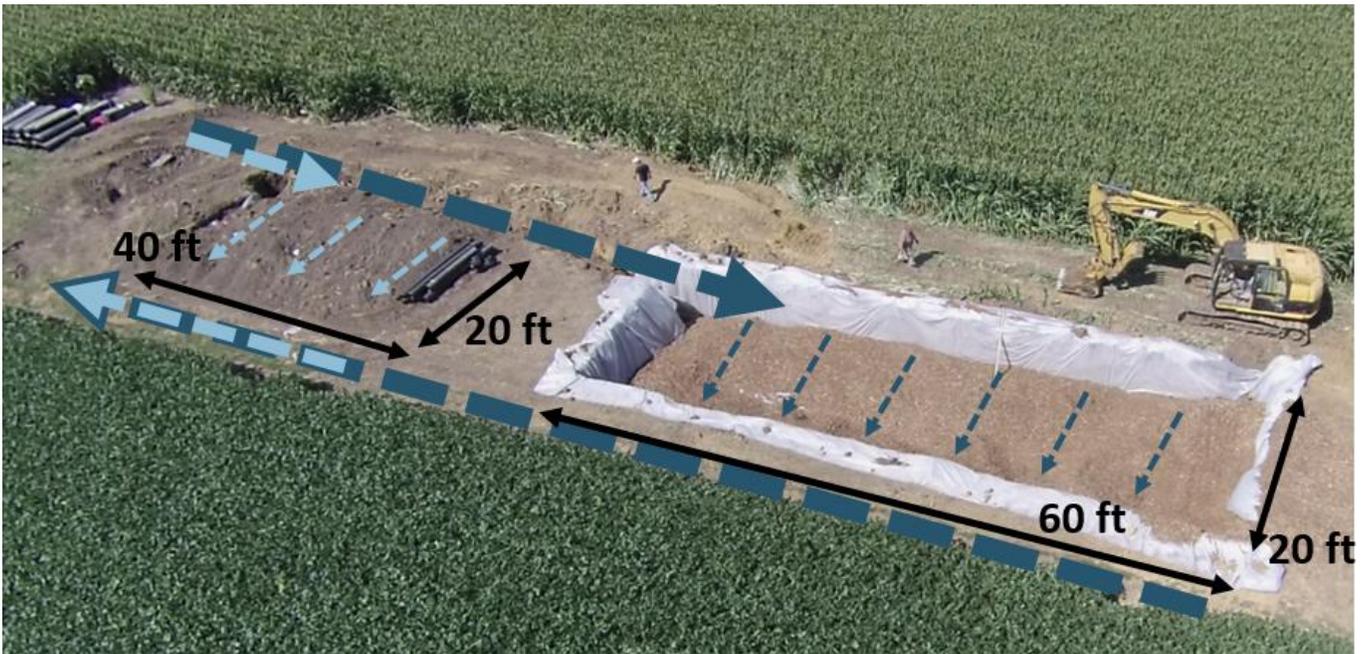
3. **Accomplishments**

a. Bioreactors

- i. Two Ditch Bioreactors (Private Farm): A conceptual design has been created for the two ditch-associated bioreactors, and a contractor is currently being sought.
  1. As a related note, the idea of an in-ditch bioreactor is generating some interest. Dr. Laura Christianson spent mid-December in Belgium evaluating a private farm ditch for an in-ditch bioreactor. She has submitted a design to the Belgian group, and construction is pending for this spring.
- ii. One High-Flow Booster Bioreactor (Monmouth Farm, UIUC): The Monmouth Research and Demonstration Center two-chamber bioreactor has been constructed and monitoring is ongoing. Currently awaiting spring drainage flow. There is a low-flow bioreactor that will remain nearly always flowing and a “high-flow booster” bioreactor that only receives tile drainage water when conditions are the wettest (**Figure 1**).
- iii. One Heat-Enhanced Bioreactor (South Farm, UIUC): Modifying bioreactor media to incorporate fill material conducive to solar-powered heating could provide an additional temperature boost to increase bioreactor nitrate removal. Lab-scale results testing this idea are currently being analyzed and written-up, and the full-size bioreactor design is nearly complete. Installation of this full-size bioreactor is pending for the UIUC Ag. Engineering Farm (South Farm) this spring.

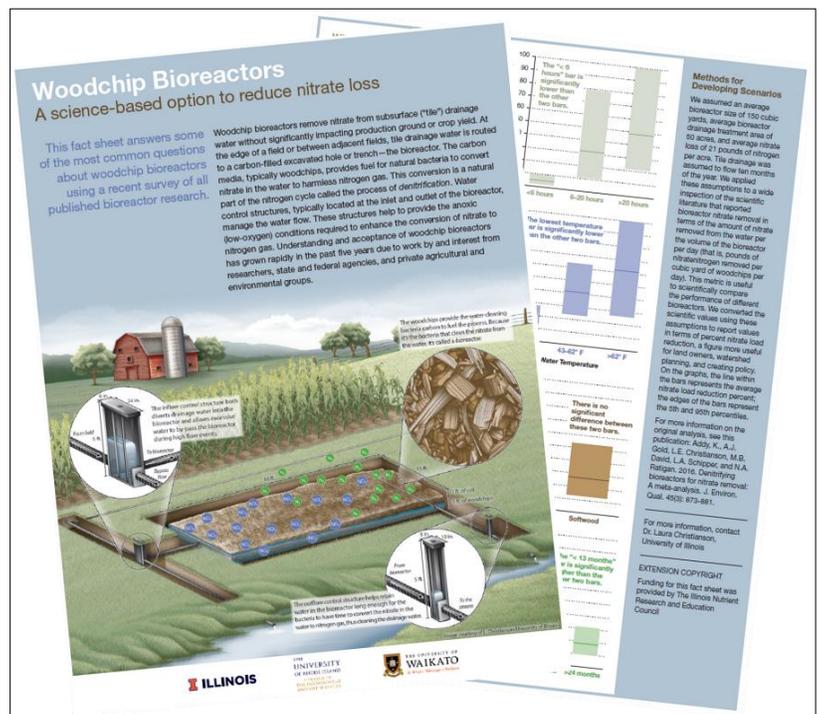
b. Outreach

- i. Between June 2017 and January 2018, Dr. Christianson and her team talked about bioreactors at 4 invited in-state meetings and 6 field events (≈450+≈650 individuals).
- ii. A new internationally-collaborative bioreactor factsheet led by the University of Illinois is nearing completion (**Figure 2**).
- iii. A general bioreactor/project webpage is being maintained at:  
<http://draindrop.cropsci.illinois.edu/index.php/i-drop-research/denitrifying-woodchip-bioreactor-projects/>



**Figure 1. Monmouth Research Center two-chamber bioreactor, the larger of which treats water under low or normal flow conditions and the smaller of which treats water that would normally by-pass.**

**Figure 2. Draft version of the new University of Illinois bioreactor factsheet.** Because we are in the very early days of research results from this study, the factsheet drew upon a recent meta-analysis of all published bioreactors studies, of which Dr. Christianson was a co-author. Another co-author of the meta-analysis is based in New Zealand, and so a metric units version of this factsheet will also be available which gives this NREC-funded factsheet international reach.



**4. For first year projects, provide evidence of progress.**

The first of the bioreactors has been installed, and we are currently awaiting spring drainage flow to initiate (Monmouth farm “high-flow booster” bioreactor). We are currently seeking a contractor for the two ditch bioreactors, and are awaiting ordered parts for the heat-enhanced bioreactor. Installation is slightly behind schedule, but we feel our outreach activities have far surpassed the timeline (**Table 1**).

**How will the research benefit the environment and/or crop production, etc.?** This research will advance bioreactor design science to provide the most practical N-removal benefit while limiting the amount of land taken out of production. Pushing the envelope with novel bioreactor modifications in “real world” settings,

will deliver new information that contributes to both woodchip bioreactor science and to demonstration efforts to encourage adoption of this practice.

**Table 1. Up-to-date timeline for “Bioreactors for Illinois...” project**

|   | 2017 |    |    |   | 2018 |    |    |   | 2019 |    |    |   | 2020 |    |    |   |
|---|------|----|----|---|------|----|----|---|------|----|----|---|------|----|----|---|
|   | W    | Sp | Su | F |
| Hire field technician   | ✓    | ✓  |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Hire MS student / student graduation                                  |      |    |    |   | ✓    | ✓  |    |   |      |    |    |   |      |    |    |   |
| <b>Objective #1: Design and build four novel bioreactors</b>          |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Task #1: Design bioreactors   |      | ✓  | ✓  |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Task #2: Install bioreactors  |      |    | ✓  | ✓ |      |    |    |   |      |    |    |   |      |    |    |   |
| Task #3: Install flow monitoring equipment                            |      |    | ✓  | ✓ |      |    |    |   |      |    |    |   |      |    |    |   |
| <b>Objective #2: Compare performance with traditional bioreactors</b> |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Task #4: Monitor N removal  |      |    |    | ✓ | ✓    |    |    |   |      |    |    |   |      |    |    |   |
| Task #5: Tracer testing   |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Task #6: Analyze & compare N removal performance                      |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| <b>Objective #3: Economic analysis (Task #7)</b>                      |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| <b>Objective #4: Funders reports (Task #8)</b>                        |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| Project webpage creation and updating                                 |      | ✓  | ✓  | ✓ |      |    |    |   |      |    |    |   |      |    |    |   |
| Peer-reviewed manuscript development/submit                           |      |    |    | ✓ | ✓    |    |    |   |      |    |    |   |      |    |    |   |
| Factsheets & Extension presentations (e.g., in field)                 |      | ✓  | ✓  | ✓ | ✓    |    |    |   |      |    |    |   |      |    |    |   |
| <b>Educational/Administrative activities</b>                          |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| <b>Research activities</b>  |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |
| <b>Communication/Outreach activities</b>                              |      |    |    |   |      |    |    |   |      |    |    |   |      |    |    |   |

**New questions created by this work:**

While this project is still in early phases, we have recently realized there is a need to not only design and monitor “novel” bioreactors being trialed across the Midwest, but also to monitor “conventional” bioreactors designed to USDA-NRCS standards. Improved upstanding of conventional bioreactors is necessary to ensure “credit” for bioreactors in state nutrient strategies is based on the best, most current science. There is also potentially room to improve the design methods and design standards for woodchip bioreactors, but this can only be done with greater understanding of how conventional designs are currently functioning.

**Table 2. Budget analysis showing expenditures aligned with budget categories.**

|                              | Budgeted                 | Spent through 01/2018 |
|------------------------------|--------------------------|-----------------------|
| A. Personnel                 |                          |                       |
| 1 UIUC MS Graduate Students  | \$0                      | \$0                   |
| 2 Academic salary and wages  | \$26,427                 | \$26,427              |
| B. Fringe Benefits           | \$14,539                 | \$3,589               |
| C. Travel                    | \$4,702                  | \$826                 |
| D. Equipment                 | \$9,000                  | \$0                   |
| E. Supplies                  | \$16,253                 | \$12,803              |
| F. Contractual Services      | \$62,900                 | \$24,989              |
| G. Other                     | \$0                      | \$0                   |
| H. Indirect Charges          | \$15,898                 | \$7,625               |
| <b>TOTAL COST (Year 1.0)</b> | <b>\$158,9932</b>        | <b>\$76,259</b>       |
|                              | <b>BALANCE REMAINING</b> | <b>\$82,734</b>       |